

The Numeracy Research and Development Initiative projects

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The National Literacy and Numeracy Plan

A major policy objective of the Australian Government is to ensure that all students attain sound foundations in literacy and numeracy. In 1997 all State, Territory and Australian Government Education Ministers agreed to a *National Literacy and Numeracy Plan* that provides a coherent framework for achieving improvement in student literacy and numeracy outcomes. The 1999 *Adelaide Declaration on National Goals for Schooling in the Twenty-First Century* (Ministerial Council on Education, Employment, Training and Youth Affairs) states that, in terms of curriculum, students should have 'attained the skills of numeracy and English literacy, such that every student should be numerate, able to read, write, spell and communicate at an appropriate level' (MCEETYA, 1999).

Numeracy, A Priority for All: Challenges for Australian Schools (DETYA, 2000) outlines how the *National Plan* provides 'a specific and focussed boost to existing initiatives by education authorities and schools to address the literacy and numeracy needs of all students' (p. 9). The *National Plan* recognises 'the importance of the early and primary school years in developing literacy and numeracy as the basis for students' progress in future schooling and effective participation in adult life' (p. 11). Key dimensions of the *National Plan*, outlined in *Numeracy, a Priority for All: Challenges for Australian Schools* are as follows:

Equity

An underlying belief of the *National Plan* is that all students are capable of making progress and achieving in literacy and numeracy: 'Through special support and focussed teaching, all students, including those who have traditionally been most disadvantaged in education, are to have a sound start in schooling' (DETYA, 2000, p. 11).

Focus on a framework for national outcomes and improvement

A second key dimension of the *National Plan* is the provision of a national framework focussing on education outcomes and improvements in literacy and numeracy: 'The development of nationally agreed standards, or benchmarks, adds to this framework by enabling education authorities to work towards achieving the national goal. Effective resourcing of areas of need and effective programmes are essential in improving students' outcomes' (DETYA, 2000, p. 11).

The *National Plan* embraces the following elements:

- assessment of all students by their teachers as early as possible in the first year of schooling;
- early intervention strategies for students identified as having difficulty;
- development of and reporting against agreed benchmarks for Years 3, 5 and 7 against which all children's achievement in these years can be measured; and
- professional development for teachers to support the key elements of the Plan.

What is numeracy?

Although numeracy and literacy are at the forefront of current educational discussion and policy, numeracy is a relatively recent concept that has different meanings for different people. The term 'numeracy' was first introduced in the *Crowthier Report* (1959) in the context of managerial skills and dispositions, but it was redefined in the *Cockcroft Report* (1982) as 'the skills and dispositions needed by ordinary people in work and daily life'. Doig (2001) notes that in England, numeracy still tends to be equated with number, although a broader meaning has been adopted in Australia, more in keeping with the term mathematical literacy used in countries such as the United States of America.

Studies have shown that many students fail to make connections between the mathematics they learn at school and situations they encounter at home, in their play, or in the workplace. Willis (1990) defined being numerate as being able 'to function effectively mathematically in one's everyday life, at home and at work' (p. vii). This notion of numeracy as a necessity for everyday life provided direction for the 1997 *Numeracy Education Strategy Development Conference* which was funded by the Australian Government and jointly convened by the Education Department of Western Australia and the Australian Association of Mathematics Teachers. The conference further developed the concept of numeracy, and provided an approach to numeracy which has been widely adopted:

To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life.

(AAMT, 1997, p. 10)

Numeracy obviously has strong connections with school mathematics and notions of numeracy were in fact embedded in the *National Statement on School Mathematics* (Australian Education Council, 1991):

As a result of learning mathematics in school all students should:

- realise that mathematics is relevant to them personally and in their community;
- acquire the mathematical knowledge, ways of thinking and confidence to use mathematics to: conduct everyday affairs such as monetary exchanges, planning and organising events, and measuring; make individual and collaborative decisions at the personal, civic and vocational levels; engage in the mathematical study needed for further education and employment;
- possess sufficient command of mathematical expressions, representations and technology to interpret information in which mathematics is used; communicate mathematically to a range of audiences.

(Australian Education Council, 1991, p. 15)

Reflecting the broader Australian view, *Numeracy = Everyone's Business* (AAMT, 1997) acknowledges that numeracy must encompass all the key concepts and skills of mathematics. With research showing that many students are unable to take their mathematics beyond the mathematics classroom, a further important aspect of numeracy is that it must pervade all areas of the curriculum:

In school education, numeracy is a fundamental component of learning, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:

- underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);
- mathematical thinking and strategies;
- general thinking skills; and
- grounded appreciation of context

(AAMT, 1997, p. 15)

Students must be able, for example, to apply their mathematical skills and understanding to interpreting and analysing media information, to making accurate measurements when working with materials, or to the planning of a school event. Students must also be able to recognise when mathematics may be useful and to select the most appropriate mathematical skills for the task.

If the level of numeracy is to be improved, traditional issues such as equity, quality teaching, resources and teacher preparedness to teach mathematics must continue to be addressed, but there is now the further issue of embedding numeracy in the whole curriculum. This raises new questions: for example, what is the impact of this whole curriculum

approach to numeracy on children's mathematical skill development? Do children apply their school-based numeracy at home? How do teachers adjust to the contextual aspects of numeracy?

With the current focus on numeracy, it is important, however, that we do not lose sight of other key goals of school mathematics included in the 1991 *National Statement on School Mathematics*, for example, that all students should:

- gain pleasure from mathematics and appreciate its fascination and power;
- realise that mathematics is an activity requiring the observation, representation and application of patterns;
- develop skills in presenting and interpreting mathematical arguments;
- appreciate that mathematics is a dynamic field with its roots in many cultures.

(Australian Education Council, 1991, p. 15)

The Numeracy Research and Development Initiative

In 2001, with funding of \$7 million, the Australian Government implemented the *Numeracy Research and Development Initiative* — one of several initiatives introduced by the Australian Government to support literacy and numeracy improvement. Other initiatives included the *National Indigenous English Literacy and Numeracy Strategy*, and the *Quality Teacher Program*.

The *Numeracy Research and Development Initiative* comprised two complementary strands: a national project strand and a strategic States and Territories projects strand. The purpose of these projects was to investigate a broad range of teaching and learning strategies that lead to improved numeracy outcomes.

National research and development projects

Further research and development projects in the identified priority areas were also undertaken at the national level. The four national projects were:

- *Numeracy in the early years: Project good start* (Australian Council for Educational Research);
- *Primary numeracy: A mapping and analysis of Australian research in numeracy at the primary school level* (Deakin University, Victoria);
- *Home, school and community partnerships to support children's numeracy* (University of Queensland);
- *Numeracy: Families working it out together — the opportunities are everywhere* (Western Australian Department of Education; School of Education, Murdoch University).

Strategic research and development projects (States and Territories)

The initiative provided funding for strategic numeracy research and development that were closely linked to improved practice at the state and regional level in schools. These projects, shown below, were undertaken by education authorities, and included partnerships with universities and other organisations.

- *What's making the difference in achieving outstanding primary school learning outcomes in numeracy?* (New South Wales Department of Education and Training; Catholic Education Commission NSW; Association of Independent Schools of NSW);
- *Researching numeracy teaching approaches in primary schools* (Victorian Department of Education and Training; Catholic Education Commission of Victoria; Association of Independent Schools of Victoria);
- *Teachers enhancing numeracy* (Queensland Department of Education; Queensland Catholic Education Commission; Association of Independent Schools of Queensland);
- *Numeracy across the curriculum* (Murdoch University, Western Australia: Centre for Learning, Change and Development);
- *Towards a profile for improving numeracy for all students* (South Australian Department of Education and Children's Services);
- *Understanding place value: A case study of the base 10 game* (Association of Independent Schools of South Australia);
- *Making sense of the complexity of constructivist mathematics classrooms* (Catholic Education, South Australia);
- *Developing computation* (Department of Education, Tasmania; Catholic Education Office, Tasmania; Association of Independent Schools of Tasmania);
- *Assessing numeracy in primary schools* (ACT Department of Education and Community Services; Catholic Education Office, Canberra and Goulburn; Association of Independent Schools of the ACT);
- *Supporting Indigenous students' achievement in numeracy* (Northern Territory Department of Employment, Education and Training; Catholic Education Office, Darwin; Association of Independent Schools of the NT).

Key findings of the Numeracy Research and Development Initiative projects

Key findings of the *Numeracy Research and Development Initiative* projects relate to five main areas:

- clarifying the meaning of 'numeracy' and its relationship to school mathematics;
- implementing a whole school approach to numeracy;
- addressing the issue of teacher pedagogy;
- implementing appropriate professional development; and
- promoting numeracy through home-school-community partnerships.

The implications of the findings for effective educational policies and strategies are now discussed in terms of these five main areas.

Numeracy and school mathematics

Although the classroom mathematics lesson must provide the basis for numeracy development, the fundamental role of numeracy in enabling people to operate effectively in 21st century society needs to be recognised and reflected across the curriculum.

Despite the current emphasis on numeracy, it would seem that numeracy is viewed by many people, including teachers, as synonymous with school mathematics skills. *Home, school and community partnerships* notes, for example, that there is a lack of awareness in schools and the community in general about the nature of numeracy and the numeracy learning opportunities inherent in home, work-related, and civic activities. The project asserts that despite the effort put into initiatives such as the *Early Years Numeracy Parent Pack*, *Family Maths*, and individual schools, more is needed in the form of community education campaigns to raise numeracy awareness and emphasise the important roles that families and community members can play in developing numerate citizens.

Kemp and Hogan (2000) and the Western Australian *Numeracy across the curriculum* project note that being numerate requires a blend of mathematical, contextual and strategic know-how. Through pre-service teacher education and professional development it is important to develop teachers' capacity to recognise numeracy events in everyday life. It is also essential for all teachers to regard themselves as teachers of numeracy and to be prepared to recognise and deal with numeracy demands arising in any area of the curriculum. As the principal agents of numeracy education, teachers may then be better able to help parents, families, other community members, and of course children themselves, to appreciate the role of numeracy in their lives — at home, in paid work, and for informed citizenship. The *Numeracy across the curriculum* project has taken a significant step in developing teachers' across-the-curriculum numeracy awareness. The project report suggests ways in which teachers might assist students to cope with numeracy demands within the school curriculum and develop their numeracy.

The poster and brochures produced by the *Numeracy across the curriculum* and *Numeracy: Families working it out together* projects will play an important role in raising numeracy awareness among teachers, in families and in the community.

A whole school approach to numeracy

The South Australian *Numeracy profile* project cites Harradine (1996, p. 4), who argues that successful school reform lies in the intersection between:

- restructuring — structural and organisational reforms such as changing the use of time and space, groupings of staff and students, staff roles, organisation of curriculum,

and use of technology;

- reculturing — changing values, beliefs, assumptions, habits, patterns of behaviour and relationships in school organisational culture; and
- changing pedagogy — concentrating on classroom 'instructional practice', the teaching and learning process and student learning outcomes.

Basing its recommendations on these three aspects, the *Numeracy profile* project presents a profile for whole school reform to improve numeracy outcomes for all students. The Queensland *Teachers enhancing numeracy project*, the New South Wales *What's making the difference?* project and the Victorian *Researching numeracy teaching approaches* project also highlight the need for whole school approaches to numeracy improvement.

During 2000 and 2001, the New South Wales *What's making the difference* project undertook case studies in forty-five schools across the state to determine the teaching strategies that result in good numeracy outcomes for primary students. In 2002 and 2003 some of these strategies were trialled in ten schools whose numeracy outcomes on the Year 3 and 5 *Basic Skills Test* were below the state average. The project also developed a numeracy assessment instrument for students in Kindergarten to Year 6. This involved testing items with over 3000 primary school students. Student outcomes at the trialling schools and matched reference schools were assessed using this instrument. Improvements occurred for students at the trialling schools in the second year of trialling. This indicates the importance of giving programmes time to embed in school culture.

What's making the difference is expected to impact on primary numeracy education:

- by identifying and describing strategies that can be replicated at the school level that will help provide quality numeracy programs for Years K–6. These strategies are documented on a CD-ROM for teachers;
- by providing a workable model for professional development for numeracy teaching improvement; and
- in developing an assessment instrument providing rich data that can be used to assess school numeracy development in a range of research contexts.

The project identified a number of factors which were found to contribute to enhanced numeracy outcomes, classifying them into three major areas: within the classroom, throughout the school and beyond the school. The factors associated with the school included a school commitment to numeracy, school policies that support numeracy, and specialised programs to support numeracy.

The *What's making the difference* project asserts that by clearly describing the factors and strategies that make a difference to numeracy teaching and then implementing them across the whole school, definite improvements in student achievement in numeracy are possible.

Pedagogy

The Queensland *Teachers enhancing numeracy* project notes that many of the project teachers initially had limited pedagogical content knowledge and that active learning which allowed meaning and connections was absent from many of the classrooms. A key finding of several projects was the improved learning that occurred in classrooms where students engaged in group or class discussions, and where teachers recognised the role of questioning and scaffolding in the learning process.

The New South Wales *What's making the difference* project emphasised the importance of language as a focus for learning, assessment to identify and accommodate differences, and purposeful pedagogy. Greater than expected growth was experienced by schools that focussed on either the language of mathematics or engaging practical resources to support concept development in numeracy.

The major outcome of the Victorian *Researching numeracy teaching approaches* project was the identification, description and elaboration of twelve scaffolding practices that contribute to improved student learning outcomes. These scaffolding practices essentially describe a range of communicative behaviours that teachers use to support students' mathematics learning. The scaffolding practices can be selected and used appropriate to purpose, for example, to explore/make explicit what is known, challenge/extend students' mathematical thinking, demonstrate the use of a mathematical instrument, or to assist students arrive at a key generalisation. In particular, the scaffolding practices support teachers to make more informed decisions about how they will meet the learning needs of all students in the most appropriate way possible. The identification of these scaffolding practices also provided teachers in the research project with a professional language to discuss teaching practices.

The *Researching numeracy teaching approaches* project suggests that by recognising the dynamic relationship between classroom cultures and scaffolding practices, teachers and professional learning teams will be encouraged to examine the type of classroom cultures they establish and the nature and role of interaction in the construction of mathematical meaning. Recognition of the complexity of classroom organisation and structure will encourage teachers to select scaffolding practices to meet specific learning needs. *Researching numeracy teaching approaches* emphasises that the critical importance and complex nature of teachers' pedagogical content knowledge should be recognised by:

- alerting teachers and schools to the interrelated and holistic nature of what needs to be known to act in-the-moment to take advantage of learning opportunities and to initiate and sustain productive conversations with students about mathematics in all settings;
- raising awareness of the importance of deep knowledge of the key ideas, strategies, learning trajectories and student misconceptions in the most commonly taught mathematical topics to support the use of scaffolding practices most effectively;

- increasing teachers' capacity to identify starting points for teaching, monitor and interpret student responses, remain focussed, probe student understanding, identify alternative models and representations as needed, and engage in deeper, richer mathematical discussions;
- increasing awareness about the specific opportunities 'good activities' present for learning mathematics and how they can be used to greatest effect supported by appropriate scaffolding practices; and
- highlighting the need for collaborative planning and a critical, reflective and collegiate practice where individual knowledge and strengths are shared to maximise the effectiveness of all.

Professional development and pre-service teacher education

The WA *Numeracy across the curriculum* project asserts that on-going professional development for teachers is a key issue in improving numeracy outcomes for students. The project suggests that teachers need to be given time to work through illustrative examples of numeracy across the curriculum in order to see the relevance and applications of the concepts and strategies in their own classrooms. There must be time for new ideas to become incorporated into thinking, for ideas to be tried out in action in the teachers' own classrooms, and time for on-going professional reflection and collegial discussion.

The Queensland *Teachers enhancing numeracy* project suggests that recognition of the critical importance of teachers' pedagogical content knowledge will encourage professional learning teams to identify their learning needs and initiate action as appropriate (for example, mentoring, team-teaching and/or targeted professional development). The Victorian *Researching numeracy teaching approaches* project asserts that access to a professional language in conjunction with opportunities for sustained, collective reflection on practice impacts powerfully on teachers' knowledge base for teaching mathematics. The project recommends implementation of the following professional development strategies:

- codifying important aspects of classroom interaction in ways that resonate with teachers' experience and make these scaffolding practices more amenable to critical review, peer evaluation and improvement;
- enabling teachers to choose and use scaffolding practices appropriate to the specific needs of individual learners;
- equipping teachers to identify students' prior knowledge and starting points for teaching through the use of scaffolding practices such as probing and modelling;
- empowering teachers to move toward a culture that values inquiry, discussion, explanations, argumentation, articulation of strategies and ideas, and the negotiation of meaning; and
- supporting teachers to remain focussed on the mathematics and work towards students making connections and generalisations through practices such as guiding, focussing, extending and reflecting/reviewing.

Pre-service teacher education is already addressing issues of teachers' pedagogical knowledge, as demonstrated, for example, by the recently commenced Australian Research Council project *Knowledge for teaching primary mathematics: How teachers' pedagogical content knowledge develops and affects classroom practices and students' mathematics achievement* (Helen Chick and Kaye Stacey, University of Melbourne). Findings from this study will no doubt influence pre-service teacher education.

Promoting numeracy through home, school and community partnerships

The New South Wales *What's making the difference?* project asserts that there must be a shared vision for numeracy learning which extends beyond the school to home and the community. Parents must be encouraged and assisted to take part in their children's mathematics.

The *Home, school and community* project notes that barriers to effective partnerships were identified as:

- short-term funding;
- dependence on individual leadership that does not empower others; and
- vertical structures where the focus is on delivering resources within a limited time frame.

Improved effectiveness of partnerships would perhaps be possible with longer term funding and more flexible accountability.

Conclusion

The *Numeracy Research and Development Initiative* has resulted in a deeper understanding of key issues surrounding numeracy education and has also opened up new opportunities for collaboration between universities and education sector authorities. The success of the numeracy projects has demonstrated the potential for research studies where teachers can participate as partners in research while engaging in their own professional development. A key outcome for the teachers involved in the projects has been the growth in their mathematical pedagogical knowledge and also in their own deeper understanding of the mathematical concepts they were teaching.

While acknowledging that 'numeracy' is broader than mathematics, many of the projects focussed on 'classroom mathematics'. Numeracy, as was intended, is fundamental to students' future ability to function as members of our society, but it is school mathematics that must continue to provide the skills and understanding which are essential elements of numeracy. Although there appears to be no single quality which characterises effective mathematics learning environments, the findings of the *Numeracy Initiative* projects point to seven key aspects which contribute to enhanced numeracy outcomes:

- school, home and community philosophies which support mathematics/numeracy learning;
- whole school approach to the improvement of numeracy;
- teachers who have strong mathematics content knowledge appropriate to the levels they are teaching;
- teachers who have a high level of mathematics pedagogical knowledge;
- teachers who recognise the numeracy in the world around us;
- respect for the learning needs of all students;
- early intervention programmes for children identified at risk; and
- effective use of resources, including technology.

The findings of the *Numeracy Research and Development Initiative* projects can be seen to have implications for numeracy teaching and learning at all levels of organisation, from government education policies to school administration and classroom practice, with many of the project findings begging further research. The *Numeracy Research and Development Initiative* is therefore playing a major role in improving numeracy outcomes for all students.

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